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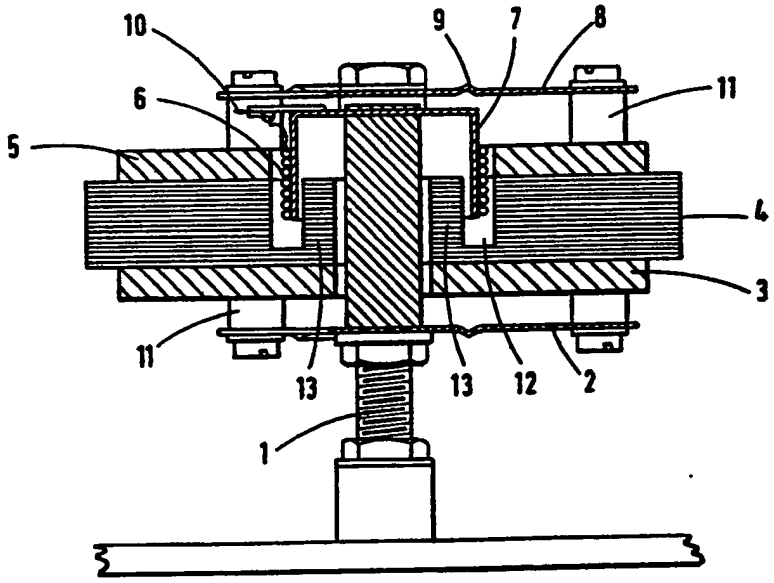

(57) Abstract

The invention relates to an electromechanical transducer for transmitting low frequency mechanical vibrations to a mechanical system, e.g. to a part of a ship's hull. The transducer, built principally in accordance with a dynamic loudspeaker configuration with a cylindrical magnet (4) and an annular air gap (12) has a center bolt (1) therethrough which is fixed to the external system to be vibrated, and also secured to a voice coil (6) in the air gap (12). Said magnet (4) is supported by springs (2, 8) which are centrally secured to said center bolt (1), located outside and in spaced relation from the flat end surfaces of said magnet (4), and are fixed to said magnet peripherally by means of distance pieces (11). The voice coil bobbin (7) is made from rolled aluminum in one piece, and said voice coil (6) is fixed thereto with an epoxy connection.

* See back of page

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ELECTROMECHANICAL TRANSDUCER FOR LOW FREQUENCY VIBRATIONS

The present invention concerns an electromechanical transducer for transmitting low frequency vibrations to a mechanical system, e.g. to a part of a ship's hull. The purpose of transmitting such vibrations is to prevent fouling by marine organisms on the outside of the hull.

The starting point of the present invention is to be found in Norwegian publicy available patent application no. 87.3306, with the same inventor as in the present invention. From NO 87.3306 is known a transducer of electrodynamical and loudspeaker-like type, where a center bolt which is fixed to the transducer voice coil extends through a central and axial bore in a substantially cylindrically shaped magnet. The magnet poles are separated by a cylindrical air gap in which the voice coil is situated, and the magnetic field is substantially radial from the central pole to the concentrically surrounding other pole. Thus, the central pole has a through bore for the center bolt extending therethrough.

Two support springs or diaphragms are provided for retaining the magnet in its position. The two diaphragm springs are arranged substantially flush with the two substantially flat and parallel surfaces of the cylindrical magnet, and the voice coil is secured with varnish onto a coil bobbin of plastic or cardboard material fixed to the center bolt outside one of the support diaphragms.

It has turned out that this construction can be improved in order to obtain a higher performance as to efficiency and maximum power emission. The present invention is related to such an improved transducer element, and the invention is defined precisely in the enclosed patent claims.

A closer description of the invention will now be given, with a detailed mention of an embodiment example of non-limiting character, and referring to the enclosed drawings, where

fig. 1 shows an axial cross section through an embodiment of a transducer in accordance with the invention, and

fig. 2 shows the same transducer in an axial view directly "from above".

It appears from fig. 1 that the transducer in accordance with the invention is intended to be fixed e.g. to a hull plate in a ship in order to impart transverse mechanical vibrations to the plate. The hull plate is equipped with a hold in which the transducer center bolt 1 is well secured by means of a screw connection. Generally, the center bolt 1 may of course be connected with the mechanical system to be vibrated, in other manners than the one shown here, for example by welding, a nail connection, a quick-coupling or similar means.

Reference numeral 4 concerns a magnet of strontium ferrite, which magnet has a cylindrical shape with concentric magnet poles and an annular air gap pole, analogous to the prior art transducer embodiment. The center pole 13 has a central and axial bore through which the center bolt 1 extends, and the magnetic field between the poles extends substantially radially from the central pole 13 to the surrounding pole, through the air gap 12.

A coil bobbin 7 projects into the air gap 12, from above in the figure. A coil 6 is wound onto the bobbin 7. It should be noted that the coil bobbin 7 which has a cup shape (standing upside down in the figure) in accordance with the invention is formed by one single piece, and is made of rolled metal, preferably aluminum. Usually such a coil bobbin is made of cardboard or plastic material, but the new coil bobbin used here, which bobbin is a central feature of the invention, is able to withstand far stronger forces than the previous constructions, and also provides much more efficient removal of heat by conduction, enabling the use of higher power. Other metals than aluminum may be used, however these metals must be rollable and have such characteristics that the magnetic field in the air gap is not influenced substantially, e.g. weakly paramagnetic characteristics.

The coil 6 is wound onto the bobbin 7 and fixed thereto in a particular manner. Instead of using a varnish as fixing agent, there is in accordance with the invention used an epoxy connection, and after winding, epoxy application and heat cure, this type of coil winding is able to withstand temperatures of

about 240°C, in comparison with a previous upper limit of about 120°C.

The coil bobbin 7 is secured with its central area (the bottom of the cup) to the center bolt 1, and consequently stays stationary in relation thereto. The aluminum bobbin 7 is more rigid than a coil bobbin of cardboard or plastic material, and thereby also provides a more ideal behaviour (i.e. lack of behaviour, or really lack of movement) of the coil 6 in the air gap 12, which air gap has as narrow a shape as possible in order to give the transducer a high efficiency.

The magnet 4 is supported by two support springs or diaphragms 2 and 8. The examplary configuration of the diaphragms or springs 2 and 8 appears most clearly from fig. 2, in which a three-arm configuration is shown. In center the support springs 2 and 8 are secured to the center bolt 1. Substantially flat arms extend from the central area, in this case three arms, to mounting positions on magnet 4.

Since it is difficult to drill into or machine the magnetic material in question of the magnet, which here preferably is strontium ferrite, external plates 3 and 5 are glued to each flat side of the magnet 4. Besides, one of these plates, here plate 3, can possibly also be used as a magnetic flux conductor, since it is constructed of soft magnetic material.

However, a central feature of the invention is the arrangement of the distance pieces 11 on the outside of plates 3 and 5, said distance pieces being used for the mounting of the diaphragms or support springs 2 and 8.

By arranging the support springs 2 and 8 in this manner, in a distance from and on the outside of the complete magnet/coil system, it is achieved that the natural system resonance more easily can be be placed in a favourable and low range, and the transducer is enabled to withstand strong accelerations (high "G" values).

Furthermore, the diaphragm springs 2 and 8 are equipped with suitably placed knee points 9 in each arm. This feature is introduced in order to obtain a precise constructional control of spring stiffness for the support springs 2 and 8,

and consequently a precise determination of natural resonance for the transducer.

The support springs 2 and 8 are preferably made of metal, e.g. brass, and possesses a high modulus of elasticity.

Reference numeral 10 represents a bracket on the coil bobbin 7 with terminal ears for electrical supply leads to voice coil 6.

When drive current is fed to the voice coil 6, magnetic and mutual forces are induced between coil 6 and magnet 4, and the magnet 4 is set in motion in relation to the center bolt 1. However, due to the magnet mass, also the center bolt 1 and the external mechanical system coupled thereto, in this case the ship's hull, is set in corresponding oscillations in opposite phase.

PATENT CLAIMS

1. Electromechanical transducer for generating low frequency vibrations in a mechanical system coupled to said transducer, e.g. in a ship's hull plate, said transducer comprising

a) a substantially cylindrically shaped magnet (4) with a coaxially arranged and cylindrical air gap (12) between concentric magnet poles and with an axial hole all the way through the central part (13) of said magnet (4), a center bolt extending therethrough, which center bolt (1) is secured to said system and in relation to which center bolt (1) said magnet (4) is movable,

b) a coil (6) for generating mutual and magnetic drive forces between said coil (6) and said magnet (4) in correspondence with the drive current being fed through the coil windings, said coil (6) being fixedly positioned in relation to the center bolt (1) and being situated in the magnet air gap (12), and

c) two support springs (2, 8) arranged in axial distance from each other, both attached to said center bolt (1) centrally and to said magnet (4) substantially peripherally,

c h a r a c t e r i z e d i n that each support spring (2, 8) is placed on a respective outside of and in a distance from said magnet (4), the substantially peripheral attachments being arranged by means of rigid distance pieces (11) between said support springs (2, 8) and the substantially flat end surfaces of said magnet (4), and that said coil (6) is wound onto a coil bobbin (7) consisting of a one-piece rolled metal of substantially cup-like shape, i.e. with a substantially flat bottom surface and a cylindrical wall surface, said coil bobbin (7) being secured centrally to said center bolt (1) with its substantially flat bottom surface.

2. Transducer in accordance with claim 1,

c h a r a c t e r i z e d i n that said coil bobbin (7) is formed from rolled aluminum.

3. Transducer in accordance with claim 1 or 2, c h a r a c t e r i z e d i n that said coil (6) is surrounded by and heat bonded to said coil bobbin (7) with an epoxy connection.

4. Transducer in accordance with any one of the preceding claims, c h a r a c t e r i z e d in that said magnet (4) is a permanent magnet of strontium ferrite.

5. Transducer in accordance with any one of the preceding claims, c h a r a c t e r i z e d i n that the dimensions, mass and magnetic characteristics of said magnet (4) as well as the elastic characteristics and shape of said support springs (2, 8) are mutually tuned for imparting a low resonance frequency to said transducer, e.g. 25 Hz.

6. Transducer in accordance with any one of the preceding claims, c h a r a c t e r i z e d in that one of or both support springs (2, 8) have a diaphragm configuration and is shaped with a central area fixed to said center bolt (1) and three arm areas extending to three substantially peripherally placed distance pieces (11).

7. Transducer in accordance with claim 6, c h a r a c t e r i z e d i n that at least one of said arm areas is equipped with a knee point (9) for adjustment of spring stiffness.

8. Transducer in accordance with any one of the preceding claims, c h a r a c t e r i z e d i n that said support springs (2, 8) consist of a metal, e.g. brass.

9. Transducer in accordance with any one of the preceding claims,
c h a r a c t e r i z e d i n that attachment plates (3, 5) for attaching said distance pieces (11) are glued to both of the substantially flat end surfaces of said magnet (4), said attachment plates (3, 5) being adapted to the remaining geometric features of said magnet (4).

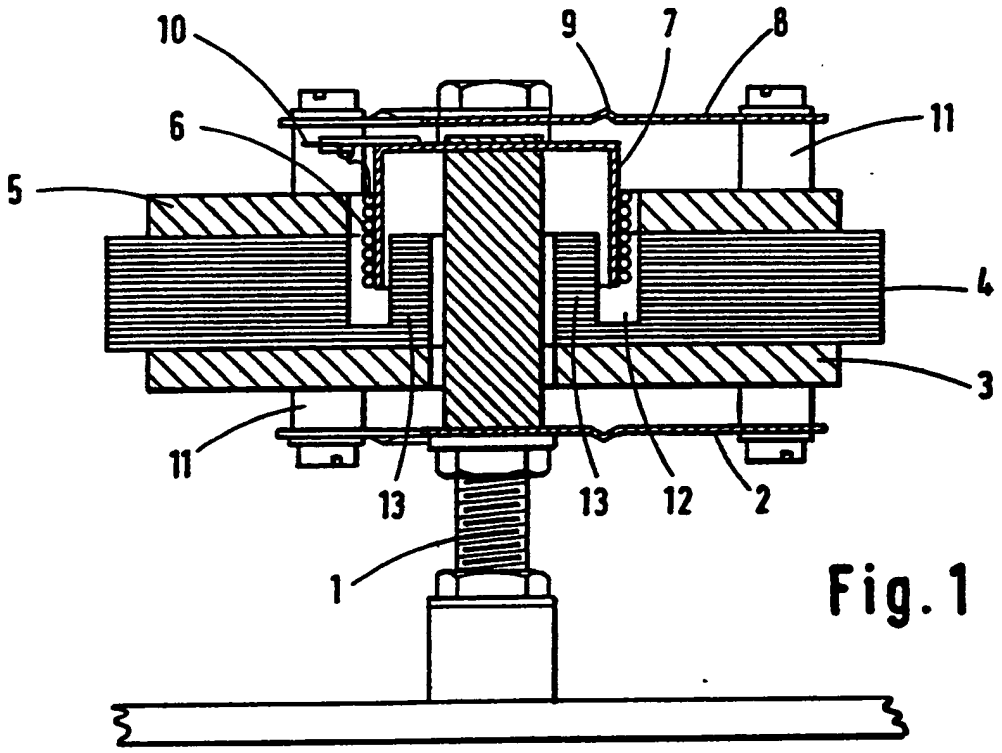

Fig. 1

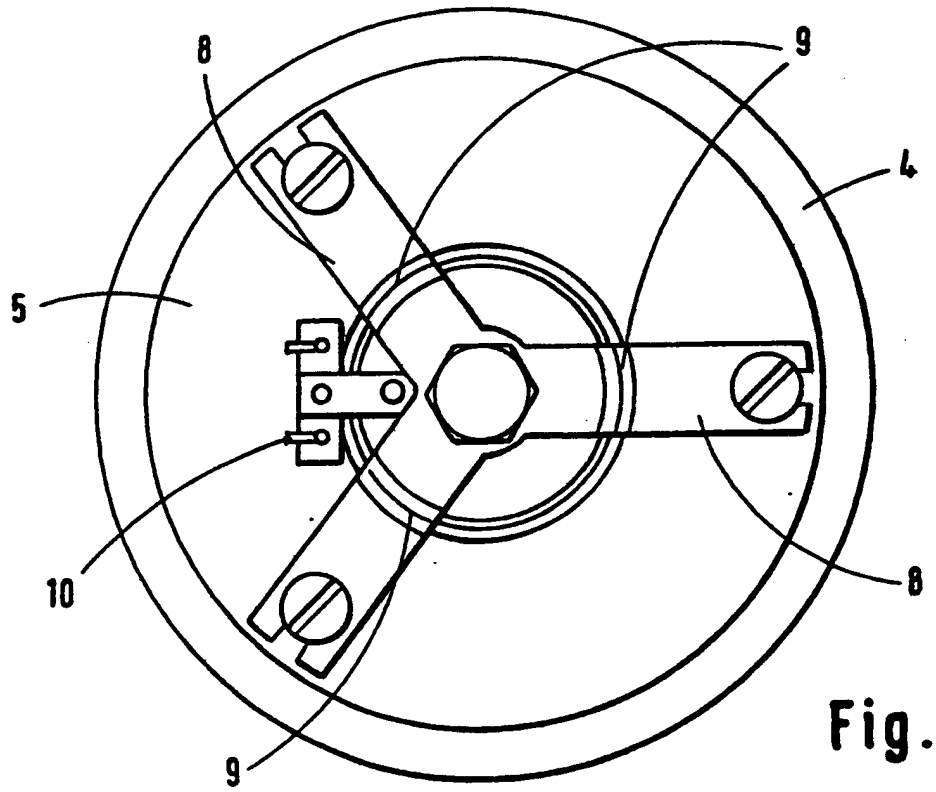

Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No PCT/NO 90/00085

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: B 06 B 1/04

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
IPC5	B 06 B 1/04, B 08 B 7/02, H 04 R 9/00 - 9/06, 9/18

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched[8]

SE,DK,FI,NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category *	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
Y	Patent Abstracts of Japan, Vol 7, No 178, E191, abstract of JP 58- 83497, publ 1983-05-19 HITACHI SEISAKUSHO K.K. --	1-9
Y	US, A, 3991286 (C.A. HENRICKSEN) 9 November 1976, see column 2, line 42 - line 50 --	1-9
Y	US, A, 2392143 (M.L. GRAHAM) 1 January 1946, see page 1, column 2, line 41 - line 46 --	1-9
Y	US, A, 3366749 (H. RIES) 30 January 1968, see figures 1-2 --	1-9

* Special categories of cited documents:[10]

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"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
8th August 1990	1990 -08- 16
International Searching Authority	**Signature of Authorized Officer**
SWEDISH PATENT OFFICE	ROLAND LANDSTRÖM

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

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Y	GB, A, 2147306 (PIONEER ELECTRONIC CO) 9 May 1985, see abstract; figure 1	9
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Y	GB, A, 894598 (M. PROCHAZKA ET AL) 26 April 1962, see page 2, line 60 - line 64; figure 1	1-9
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.PCT/NO 90/00085

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the Swedish Patent Office EDP file on 90-06-27 The Swedish Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A- 3991286	76-11-09	NONE		
US-A- 2392143	46-01-01	NONE		
US-A- 3366749	68-01-30	NONE		
NO-A- 873306	89-02-08	NONE		
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